4 CODES, STANDARDS, AND THE *NEHRP RECOMMENDED PROVISIONS*

"To many members of the design and construction industry, codes and standards can be intimidating, complicated, and vastly confusing with variations both among and within jurisdictions."
—An Architect's Guide to Building Codes and Standards, AIA 1991.

"In reality, the quality of a building depends much more upon the talent of the engineer, the architect, and the builder than it does upon the code.
—James Gere and Haresh Shah, Terra non Firma, 1984

CODES, PROVISIONS, AND STANDARDS

A building code is a set of legal requirements intended to ensure that a building is so located, designed, and constructed that, if it is subjected to natural or man-made destructive forces, it will present no significant threat to the life, health, or welfare of its occupants or the general public. In addition, a code is intended to ensure *uniform minimum standards of health and safety* with reasonable economy and to obviate the need for expensive and difficult studies for every building project, large or small.

In the absence of a code that covers earthquake resistance, seismic design would require lengthy consultations with geologists, seismologists, and engineers every time a new building was planned. As a result, buildings in the same general location probably would be designed using different assumptions concerning earthquake forces and engineering design depending on the opinions and knowledge of the people involved.

Seismic codes are based on knowledge derived from experience, laboratory testing, and theoretical analysis. The *NEHRP Recommended Provisions* is a source document providing a knowledge base that represents a consensus, both of seismic experts and affected members of the building community, on the most up-to-date criteria for designing buildings against earthquake effects. The full title of the current edition of the document is *NEHRP Recommended Provisions for Seismic Regulations for New Buildings, 1994 Edition: Part 1, Provisions, and Part 2, Commentary*; maps also are included (FEMA Publications 222A and 223A. (The two-part document and maps is referred to in this publication as the *Provisions*.)

Thus, the *Provisions* is not a code but can serve as the basis for a code or be incorporated into an existing code. (How building codes are used to regulate design and construction in the United States is explained in Appendix A.)

Both codes and the *Provisions* may refer to *standards*. Standards present acceptable design and construction criteria developed by those with expert knowledge, but they are not law unless incorporated by reference within a code. Standards provide for levels of design, manufacturing, and construction that often are embodied in codes. In addition, standards often are voluntarily used by designers to specify the quality of materials and components of construction.

Building codes do not explain how to design a building. Rather, they provide the minimum criteria and standards to which a building must be designed and assume that the designer is a professional who is knowledgeable about the nature of the seismic hazard in general and is experienced in earthquake-resistant building design.

THE IMPORTANCE OF THE *PROVISIONS*

The goal of the *Provisions* is:

> ". . . to present criteria for the design and construction of new buildings subject to earthquake ground motions in order to minimize the hazard to life for all buildings, to increase the expected performance of higher occupancy structures as compared to ordinary structures, and to improve the capability of essential facilities to function after an earthquake. To this end, the *Provisions* provides the *minimum criteria considered prudent and economically justified* for the protection of life safety in buildings subject to earthquakes at any location in the United States. The *Provisions* document has been reviewed extensively and balloted by the building community and, therefore, it is a proper source for the development of building codes in areas of seismic exposure."

Even if it were technically possible to design for "zero risk," economic considerations would prevent any such attempt as would requirements concerning building function and appearance. Thus, the *Provisions* and seismic codes and standards reflect some degree of compromise.

The objective of the *Provisions* therefore is to present the *minimum requirements* to provide reasonable and prudent life safety for building occupants. For most structures designed and constructed according to the *Provisions*, it is expected that structural damage from even a major earthquake would likely be repairable; however, this would depend upon a number of factors including the type, materials, and details of construction used. For ground motions larger than the design levels, the *Provisions* intend to reduce the likelihood of building collapse; however, it is possible that a building would be damaged beyond repair.

Prediction of building performance in earthquakes is uncertain, and building owners and the public are increasingly concerned about possible damage, particularly since it is now generally acknowledged that adherence to seismic building codes cannot *guarantee* a damage-free structure.

A building code, or set of guidelines such as the *Provisions*, cannot solve the whole problem of building safety. The 1994 *Provisions* discusses the uncertainty in a number of the quantities that are used to determine the forces on the building and how the building will resist them. For example, the estimate of the seismic hazard – the size of the earthquake – may be overestimated or underestimated by as much as 100 percent, and the properties of the soil may be off by as much as 40 percent up or down. In estimating the seismic forces, the properties of materials may vary by 20 percent, the estimate of building weight may vary by 15 percent, and the selected structural system's ability to resist seismic forces may vary by as much as 40

percent. (These numbers represent the considered opinions of a number of experts in the field). Given these uncertainties with respect to estimation of earthquake forces that may be imposed on a building and the building's ability to resist them, the *Provisions* embodies some "conservatism" – that is, a "factor of safety" is built into the equations and coefficients that are used to establish the design criteria.

Beyond the estimation of forces and capacities in the *Provisions*, other factors affect the actual performance of the building. The *Provisions* requirements must be correctly interpreted by the building engineer, the materials must meet specifications, and materials and components – particularly structural connections – must be correctly installed on the site. Inspection procedures, whether by a community's regulatory agency or the owner's representatives, must be properly implemented to ensure that the building is constructed strictly according the plans and specifications.

An objective – although not a guarantee – for buildings designed according to the *Provisions* is that if the design ground motion (i.e., the level of shaking determined by procedures in the *Provisions* against which the building is required to be designed) were to occur, structural collapse of all or part of the building should not be expected. However, life-threatening damage may be expected in 1 to 2 percent of the buildings with 1 percent of the occupants of these damaged buildings possibly becoming casualties. If ground motion *twice as strong* as the design motion were to occur, one might expect from 1 to 2 percent of the buildings to collapse and, at three times the design motion, from 5 to 10 percent. The percentage of buildings with life-threatening damage might rise to 10 and 50 percent, respectively.

These objectives reinforce the point that seismic codes are aimed at reducing the possibility of life-threatening collapse but that some building damage may occur even in a well designed building that is subjected to a severe earthquake.